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TITLE: PRELIMINARY MODELING OF THE TMI-2 ACCIDENT WITH MELPROG-TRAC

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PRELIMINARY MODELING OF

THE TMI-2 ACCIDENT WITH MELPROG-TRAC

by

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INTRODUCTION

In support of Nuclear Regulatory Commission and Organization for Economic Co-operation and Development (OECD)-sponsored Three Mile Island–Unit 2 (TMI-2) Analysis Exercise studies, work has been performed to develop a simulation model of the TMI-2 plant for use with the integrated MELPROG-TRAC computer code.[1,2,3,4,5] Numerous nuclear power plant simulation studies have been performed with the TRAC computer code in the past.* Some of these addressed the TMI-2 accident or other hypothetical events at the TMI plant.[6,7,8] In addition, studies have been previously performed with the MELPROG-TRAC code using Oconee-1 and Surry plant models.[9,10,11,12] This paper describes the preliminary MELPROG-TRAC input model for severe accident analysis.

Initial modeling efforts were directed at converting earlier MELPROG and TRAC input decks to work with the latest version of the integrated code. Subsequent efforts

* More than 125 full-scale plant calculations have been performed at Los Alamos in the last several years. These calculations covered numerous hypothetical accidents (steam-generator tube rupture, loss of feedwater, small-break loss-of-coolant accident, boron dilution, anticipated-transient without scram, loss-of-offsight power, etc.) for most types of nuclear steam supply systems (Babcock & Wilcox, Westinghouse, and Combustion Engineering. A listing of these calculations and associated report numbers is available by writing to the author at MS K555, Los Alamos National Laboratory, Los Alamos, NM 87545.

involved adjusting the existing models to more accurately predict the initial conditions and the accident sequence to the end of Phase 2 (174 min). The initial conditions and accident sequence are shown in Tables 1 and 2 with comparisons given with preliminary calculational results obtained using early versions of the input model.

INPUT MODELS

The preliminary MELPROG input model is depicted in Figure 1. It consists of the following structures to define the reactor pressure vessel and associated principal vessel internals:

vessel bottom head	**flow distributor**
in-core instrumentation tubes	**lower grid forging and shell**
lower grid support posts	**lower grid distributor plate**
lower grid rib section	**upper grid rib section and ring**
control rod assembly guide tubes	**upper support plate**
vessel top head	**thin metal in upper head**
core barrel	**baffle plate**
formers	**plenum cylinder**
core support shield	**vessel wall plus thermal shield**

The preliminary MELPROG model also contains a core model that includes a basic representation of the fuel rods and the full-length control rods. The basic fuel rod consists of an axial fuel/gap/cladding region with an upper region for the fission gas plenum (spring, spacer pellet, end plugs and spacer grids not explicitly modeled). The full-length control rods are similarly modeled with an axial absorber/cladding region.

The TRAC input model for the primary system is depicted in Figure 2. It models both hot legs, all four cold legs, the reactor-coolant pumps and the pressurizer. In addition, it models both steam generators and sufficient operator and equipment control to capture operator and equipment actions during the system transient. The secondary system (not shown) includes only sufficient components to accurately predict primary-to-secondary heat transfer and steam generation. The feedwater flows (both main and auxiliary) and steam lines are provided as boundary conditions.

DISCUSSION

The modeling of the TMI-2 accident presented a challenge, requiring accurate establishment of initial and boundary conditions. This requirement was evident from initial calculations that did not show the repressurization that was actually observed in the plant after the pressurizer power-operated relief valve was closed. The need to accurately model initial and boundary conditicns was further indicated by the incorrectly predicted draining of the pressurizer. It has been postulated that this early draining was most likely caused by excessive vessel liquid inventory provided by our earlier preliminary model. This excessive liquid inventory allowed the primary system to become overcooled during Phase 1 (prior to 100 minutes), and prevented the simulation of core damage towards the end of Phase 2 (prior to 174 minutes).

Current efforts are directed at establishing more accurate initial and boundary conditions and developing a more detailed core model for the MELPROG input. The initial and boundary conditions are consistent with the data base that has been provided as part of the Initial-Conditions Boundary-Conditions (ICBC) software to support the TMI-2 Analysis Exercise.[13] The core model is based on review of plant data developed for earlier modeling of the TMI-2 accident and more recent plant data provided to TMI-2 Analysis Exercise participants.

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TABLE 1. TMI-2 SEQUENCE OF EVENTS

Time (s)		Event
TMI-2	MELTRAC	
0	0	Loss of main feedwater
0	0	Turbine trip
0	0	Steam stop valves in steam chest close
0	0	AFW pumps start
4	5.2	Pressure>15.65 MPa; PORV opens
5	--	Turbine bypass valves open
8	8	Reactor trips
15	14.6	PORV does not close; pressure<15.65 MPa
31	--	AFW valves open
41	41	HPI on
90	no	Upper head of vessel saturated
90	93	Steam generators boil dry
300	326	Primary system repressurization
450	455	Pressurizer full
480	493	Primary pressure decreases (AFW on)
4380	4422	Loop B RCPs trip, Loop-A voiding
6000	6048	Trip A-loop RCPs **(end Phase 1)**
6720	7482	Superheat in Loop-A hot leg - core uncovery
7500	7482	Primary system repressurization starts again
7800	no	Cladding failures (1100 K) followed by Zirc oxidation (1800 K) and fuel liquefaction
8340	8340	Pressurizer PORV block valve closed
10440	10400	Restart of Loop B-2 RCP **(end Phase 2)** & End of Calculation

TABLE 2. TMI-2 PLANT CONDITIONS: INITIAL

PARAMETER	TMI-2	MELTRAC
AUX feedwater injection SG-A (kg/s)	0.0	0.0
AUX feedwater injection SG-B (kg/s)	0.0	0.0
Calculated PORV flow rate (kg/s)	2.59 ± 0.517	0.0
Cold leg temperature 1A (K)	561 ± 1.06	564.3
Cold leg temperature 1B (K)	565 ± 1.06	564.1
Cold leg temperature 2A (K)	548	564.3
Cold leg temperature 2B (K)	565	564.1
Hot leg temperature A-loop (K)	592 ± 0.633	591.9
Hot leg temperature B-loop (K)	592 ± 0.633	591.9
HPI makeup based on expected results (kg/s)	5.44	5.44
letdown flow (kg/s)	4.18 ± 0.035	4.11
Main steam temperature A (K)	586 ± 1.17	584.3
Main steam temperature B (K)	586 ± 1.17	584.3
Pressure-primary (MPa)	15.2 ± 0.0752	14.93
Pressurizer level (m)	5.77 ± 0.61	5.55
RC flow rate loop A (kg/s)	8280 ± 178	8603
RC flow rate loop B (kg/s)	8560 ± 184	8605
Reactor power (MW)	2700 ± 39	2689
Steam gen. A feedwater flow (kg/s)	723 ± 13.4	720
Steam gen. B feedwater flow (kg/s)	717 ± 13.4	720
Steam gen. feedwater temp. (K)	513 ± 0.989	512.4
Steam generator A pressure (MPa)	7.31 ± 0.112	6.24
Steam generator B pressure (MPa)	7.24 ± 0.112	6.24
TOT pressurizer heater group power (MW)	1.39	0.39

Figure 1. TMI-2 MELPROG VESSEL MODEL

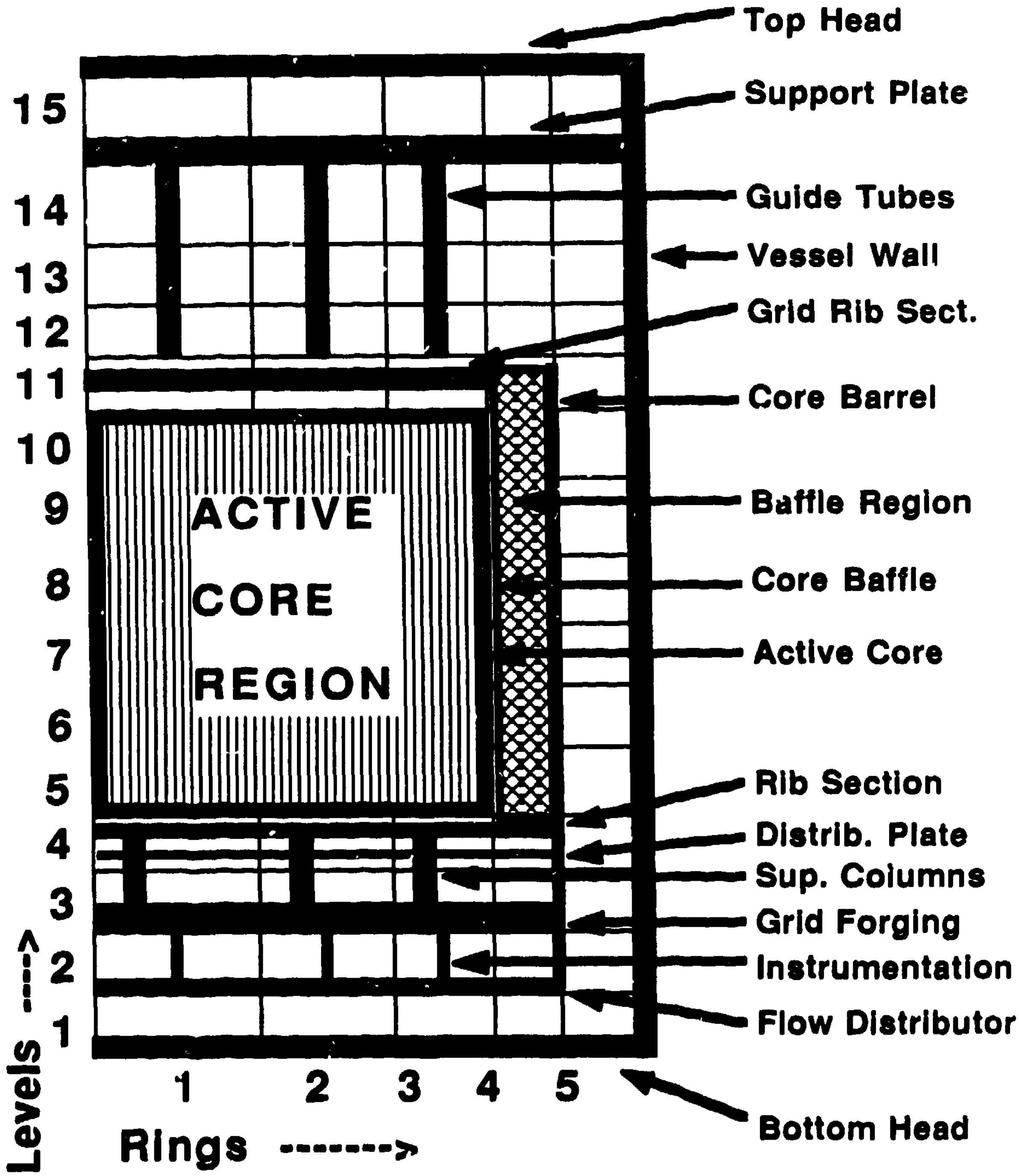

Figure 2. TMI-2 TRAC PRIMARY-SYSTEM MODEL